Remarks

Claims 1, 10, 18-23 and 26, 27 have been canceled, and claims 2-9, 11-17, 24, 25, 28-31 and 33-35 have been amended. New claims 36-43 have been added, and claims 2-9, 11-17, 24, 25 and 28-43 remain in the application. Re-examination and reconsideration of the application are respectfully requested.

The new independent claims relate to a wastewater source control system that, under a high flow sewer main condition, reduces entry of sanitary waste from a wastewater source, for example, a building drain, into the sewer main. By blocking a sewer service line in response to detecting the high flow sewer main condition, building wastewater is detained and accumulated in the sewer service line; and thus, the amount of sanitary waste that is introduced into the sewer main under a high flow condition is substantially reduced. With the claimed wastewater source control system, in the event of a sewer overflow, substantially less sanitary waste pollution will be introduced into watercourses, streams, rivers, lakes, oceans, and other bodies of water receiving the sewer overflow. The invention is effective to reduce pollution in either a Combined Sewer Overflow or a Sanitary Sewer Overflow situation. When the probability of a sewer overflow is past, that is, upon detecting a subsequent lesser flow in the sewer main, the sewer service line is unblocked; and the accumulated sanitary waste from the building drain then flows into the sewer main.

Claims 1-21 are rejected under 35 U.S.C. §102(b) as being anticipated by Hungerford, U.S. Patent No. 5,506,791. Independent claims 1, 10 and 18 have been canceled and replaced by new independent claims 36, 38, 39, respectively; and therefore, the discussion to follow will be with respect to the new claims 36, 38, 39. As shown in Fig. 6, Hungerford has a multi-function flow monitoring device 1 mounted in a manhole, which is responsive to a monitoring sensor 31 submerged in sewer water in a sewer main. The sensor can take many forms depending on what is being monitored. The monitoring device is microprocessor controlled and has the capability of controlling an external device, such as a pump. Thus, as described at col. 18, line 61, the monitoring device may be used to operate a pump in response to higher sewer water levels, presumably to pump fluid from the sewer main. Thus, Hungerford relates to a system that has the capability of operating pumps, presumably in a sewer main, in response to detected higher sewer main flows.

In contrast to Hungerford, claims 36, 38, 39 relate to a wastewater control system for reducing entry of sanitary waste from a building drain into a sewer main in response to a high flow in the sewer main. Further, claims 36, 38, 39 recite the following elements that are not found in Hungerford:

1. A sewer service line connecting a building drain to a sewer main.
2. A flow control device connected in the sewer service line.
3. An actuator that operates the flow control device to block the sewer service line in response to a higher flow in the sewer main, thereby accumulating wastewater in the sewer service line and preventing its entry into the sewer main. Thus, in an event of a detected sewer main high flow condition, entry of sanitary waste into the sewer main is blocked and thus, reduced. Consequently, in the event of a sewer overflow, pollution in receiving waters is reduced. The actuator, in response to a lesser flow condition, operates the flow control device to unblock the sewer service line, thereby permitting wastewater accumulated in the sewer service line to flow into the sewer main. Therefore, Applicant submits that claims 2-9, 11-17 and 36-41 are patentable and not anticipated under 35 U.S.C. §102(b) by Hungerford.

Claims 22-35 are rejected under 35 U.S.C. §103(a) as being unpatentable over Hungerford. Independent method claims 22, 26 are canceled and replaced by new independent claims 42, 43, respectively. Independent method claim 30 is amended to be dependent on new method claim 42. The new method claims 42, 43 recite steps of blocking a sewer service line in response to a high sewer main flow or rainfall, respectively, and accumulating wastewater in the sewer service line to reduce entry of sanitary waste into the sewer main. Thereafter, the sewer service line is unblocked to release accumulated wastewater into the sewer main. The claimed methods are not shown, described or obvious in view of Hungerford, which simply demonstrates a capability of operating pumps in response to a sewer main high flow condition. Therefore, Applicant submits that claims 24, 25, 28-35, 42 and 43 are patentable and not obvious under 35 U.S.C. §103(a) in view of Hungerford.

As requested in the Office Action, Applicant is submitting another copy of the reference cited by Applicant. Apparently, a first copy submitted by Applicant upon filing the application became separated from the application.

Applicant submits that the application is now in condition for allowance and reconsideration of the application is respectfully requested. The Examiner is invited to contact the undersigned in order to resolve any outstanding issues and expedite the allowance of this application.

Respectfully submitted,

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ANALYSIS OF SOURCE CONTROL FOR DOMESTIC WASTEWATERS

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ABSTRACT

In a large number of urban watersheds, a combination of upstream approaches for the control of the major CSO pollution sources may be more cost-effective than current end-of-pipe solutions. Source control has been directed largely at the control of rainfall runoff and stormwater flows. This paper concentrates on the control of domestic wastewater as a part of integrated source control by preventing its mixing with storm water in combined sewer systems during rainfall runoff periods, thereby avoiding or reducing CSOs. CSO data from a typical urban watershed of approximately 100 hectares in Cincinnati are used as a prototype for illustration purposes.

KEYWORDS

Analysis; combined sewers; domestic wastewaters; overflows; source control; urban watersheds.

INTRODUCTION

Source control is an important approach for the prevention of CSO pollution in urban drainage. The major sources generally recognized for possible control include:

* Stormwater Runoff
* Domestic or Sanitary Wastewater
* Commercial and Industrial Wastewaters

In a large number of urban watersheds, a combination of upstream approaches for the control of all of the above may offer a more cost-effective solution than current structural end-of-pipe solutions. Although integrated source control may be applied to all wastewaters, including commercial and industrial sources, this paper concentrates on the control of domestic wastewater through the prevention of its mixing with storm water in combined sewer systems during rainfall runoff periods. Domestic or sanitary wastewater (sewage) as defined here refers to the liquid material collected from residences, business buildings, and institutions.

DOMESTIC WASTEWATER SIGNIFICANCE IN CSOs

Comparison of pollutant concentrations in urban drainage

For general comparison, Table 1 provides a listing of typical average concentrations for the main components in urban drainage as reported in several countries.

Table 1. Typical pollutant concentrations of components in urban drainage

Pollutant (mg/l) (location)	Rainfall	Domestic Wastewater	Urban Stormwater	CSO
COD:				
Cincinnati, Ohio	16	400-500	111	
Durham, North Carolina			179	
Denmark			50	
Germany		638	120	
BOD:				
Cincinnati, Ohio		225	11	84
Durham, North Carolina			15	
Sweden			17	
Total N:				
Cincinnati, Ohio	1+	40	2	6
Germany		49	6	
Suspended Solids:				
Cincinnati, Ohio	13	250	93	155
Ontario, Canada cities			108--340	
Fecal Coliform (count/100 ml):				
Cincinnati, Ohio		$>10^7$	500--10^4	10^6
Durham, North Carolina			7000--86,000	
Ontario, Canada cities			2000	

Ref. for above data: Preul (1990-5); Cuthbert, *et al* (1995); Bryan (1971); Mikkelsen, *et al* (1993); Kollatsch (1993); D'Andrea and Maunder (1993); Whitely, *et al* (1993).

The above Table 1 numbers are intended only to provide the general order of magnitude for comparing domestic wastewaters with stormwater runoff. It is recognized that storm flow concentrations are generally very high in the first flush and subside in the sustained flow. The percentage of domestic wastewater flow in CSOs is a continuous variable during the period of storm runoff and represents a less significant concentration as the stormwater flow increases, such as at the peak discharge of a runoff hydrograph for the outlet of a typical urban watershed. For example, during storm runoff at peak flow, a combined sewer designed to carry a maximum of 100 times the dry weather flow (100 DWF) would be expected to carry a domestic wastewater component (used here as equivalent to 1.0 DWF) of only 1.0% of the flow at peak discharge, whereas at a combined sewer total flow of 3 DWF, the domestic wastewater flow would be about 33%.

Significance of domestic wastewater component in CSOs

The significance of the domestic wastewater component in combined sewage varies with both flow rate and time, as in a hydrograph or pollutograph. Typically, the pollution may be viewed quantitatively over an annual period, however during certain receiving water periods, overflow concentrations may be more critical than in long-term quantity accounting. In terms of the domestic wastewater concentration portion of a certain pollutant in a CSO mixture, the following equation is used for illustration purposes:

$$\mathrm{CCSO} = [(\mathrm{CDW})(\mathrm{NDWF}) + (\mathrm{CSW})(\mathrm{NDWF})]/(\mathrm{total\ NDWF}) \qquad (1)$$

where:

CCSO = pollutant concentration in CSO discharge
CDW = pollutant concentration in domestic wastewater portion of CSO
CSW = pollutant concentration of stormwater portion of CSO
NDWF = number of multiples of dry weather flow

The above equation is now used to show the effects of stormwater dilution in CSOs. In the Cincinnati combined sewer system, the CSO outlets are generally set to overflow at 3 DWF, therefore this is used in basic calculations below for comparative calculations with increasing stormwater dilution factors.

$$CCSO = [(225\ mg/l)(1.0\ DWF)+(10\ mg/l)(2.0\ DWF)]/(3\ DWF) = 82\ mg/l\ BOD \tag{2}$$

$$CCSO = [(225\ mg/l)(1.0\ DWF)+(10\ mg/l)(9.0\ DWF)]/(10\ DWF) = 32\ mg/l\ BOD \tag{3}$$

$$CCSO = [(225\ mg/l)(1.0\ DWF)+(10\ mg/l)(99\ DWF)]/(100\ DWF) = 12\ mg/l\ BOD \tag{4}$$

A comparison of the above results shows that basic domestic wastewater concentrations become increasingly diluted with higher stormwater flows, as expected. Because of this increasing dilution factor, domestic wastewater may appear to have a negligible effect as compared with the high pollutant concentrations carried with the first flushing of watershed surface deposits. This becomes increasingly true with highly intense, short duration storms resulting in high CSO discharges of a lower frequency (low number per year); however, the domestic wastewater component takes on more significance in the more frequent (high number per year) smaller CSO discharges due to its higher concentration percentage. Therefore we may conclude that domestic flows are more significant in terms of concentration during smaller more frequent CSO discharges, and less significant in high discharges of a lower frequency for purposes of meeting stream standards. Since smaller CSO discharges are more frequent, the elimination or reduction of the domestic component would be advantageous, particularly with regard to certain constituents and especially BOD, COD, and fecal coliform counts.

SOURCE CONTROL OF DOMESTIC WASTEWATER

If domestic wastewater can be detained on-site or near its source during stormwater runoff periods, mixing with stormwater would be avoided and this source of pollution eliminated in CSOs. To facilitate this method of control, a suitable form of detention with appropriate operation during runoff periods will be needed during at a location upstream from connection to the combined sewer. Therefore, it is necessary to analyze expected domestic wastewater discharges with regard to flow quantities, pollution potential, timing, and required volumes for detention.

Domestic wastewater discharges

The objective here is to examine domestic wastewater discharges so as to be able to calculate detention volumes necessary to bridge a storm runoff event. It is assumed that appropriate facilities can be developed if the method is shown to be a worthy investment in CSO attenuation. Detention volume requirements for containing domestic wastewater discharge will depend on the time length of the storm event and the wastewater discharge volume generated during a selected time period necessary to bridge most storm events.

Domestic Wastewater Discharges - Flow Quantities. Siegrist (1983) and Seaker and Sharpe (1988) summarized data from several U.S.A. studies and found that the range of water required for toilet flushing ranged from about 36 to 100 litres per capita per day (lpcd). Nationally, toilet water use is estimated to constitute 38% to 45% of interior water use, and total interior domestic usage would be in a range of about 90 to 250 lpcd. These figures are based on prevailing plumbing fixture usage; more recent water conservation standards have been adopted in many states and are expected to reduce this usage by as much as 50%. The new indoor water conservation standards apply to toilets, shower heads, washing machines and faucets. Whereas the standard American toilet usage has ranged from 14 to 20 litres of water per flush, the newly mandated conservation controls for toilet fixtures will reduce the standard flush to about 6 litres per flush, which has long been the maximum flush specified in some European countries. Other conservation controls will be required through limitations in fixture flow rates. For purposes of analysis in this paper, it is assumed that source control of domestic wastewaters will apply largely to new or retrofitted construction of residential housing and commercial/public buildings. According to projections by Siegrist (1983) the future U.S.A. interior domestic usage may be more in the range of 60 to 78 lpcd which then would calculate to an average indoor wastewater discharge of approximately 170 to 220 litres/day for the average dwelling unit of 2.8 persons as in typical Cincinnati residential watersheds. As a comparison, Butler and Graham (1995) have reported an interior domestic wastewater discharge volume of 245 litres/day/dwelling unit for an up-scale southeast England urban area having an average occupancy of 2.71 persons per unit. This may be representative of future discharges in the U.S.A. under new water conservation controls.

Expected Domestic Wastewater Quality and CSO Effects. The strength of domestic wastewater is expected to increase significantly with recently mandated conservation controls requiring minimum flow plumbing fixtures in the U.S.A. Flow volumes will be reduced whereas wastewater strength will be increased. Likewise the concentrations of pollutants discharged to a combined sewer system and in CSOs will be increased. Based on a simple mass balance, Siegrist (1983) proposed the following relationship to predict the increased concentrations of domestic wastewater pollutants under reduced flow conditions:

$$C_R = C/(1-R) \tag{5}$$

where:

C_R = mg/l pollutant concentration under reduced flow conditions
C = mg/l pollutant concentration under previous flow conditions
R = reduction in flow expressed as a decimal fraction (0-1.0)

For example, a 40% reduction in daily flow would result in a 67% increase in a pollutant concentration. Therefore a typical domestic wastewater at 225 mg/l BOD would increase to a strength of 376mg/l BOD and CSO concentrations will likewise be affected particularly in the lower CSO range when stormwater dilution is lower.

Typical Rainfall Durations Causing CSOs. The "Bloody Run" watershed, Cincinnati, Ohio, of approximately 1,000 hectares area, is used here to provide example data for establishing duration times to bridge periods of storm flow in a combined sewer so as to avoid the mixing of domestic wastewaters with storm drainage. This watershed has been studied over a period of years for urban runoff research by Preul (1974; 1990-95) and by Preul and Papadakis (1974). "Bloody Run", as it is named for certain historical reasons, is approximately 50% residential area with the remainder including about 20% commercial/shopping center plazas, 10% schools and public facilities, 10% open areas, 5% industrial, and 5% roads and expressways. The residential area is composed of both single family and multi-family housing with an average of 2.8 persons per dwelling unit. The Cincinnati climate is continental with wide ranges of temperatures from winter to summer and an average rainfall of about 1050 mm per year. Bloody Run watershed rainfall and CSO observations recorded during a typical year have been used for an analysis of the probable time lengths of storm events causing CSOs; total rainfall for the year was near normal with a typical number of CSOs. During this period there were 76 fully recorded storm events which caused CSOs. These CSO storms varied in rainfall depth from about 2.5 mm up 60 mm. The long-term mean number of days having precipitation of 0.25 mm is about 130 days and it estimated that it takes more than 5.0 mm to cause a CSO depending on the storm intensity and antecedent conditions of the watershed. An analysis of the data for the period of record showed that there was no perceptible correlation between "Precipitation Duration" and "Rainfall Depth", in other words short and long duration rainfalls did not result in small or large rainfall amounts, but varied widely due to rainfall intensities and other hydrologic conditions. However the Table 2 data below show that there was a significantly higher frequency of short duration storms which caused CSOs, as would be expected.

Table 2. Bloody run watershed rainfall-CSO data for a typical year

Rainfall Duration in minutes	Total Number of CSOs during year	Cumul. CSOs	Percent of CSOs
0 to 60	22	22	29%
61 - 120	19	41	54%
121 - 180	8	49	65%
181 - 240	9	58	76%
241 - 300	6	64	84%
301 - 360	4	68	90%
361 - 420	2	70	92%
421 - 480	1	71	94%
481 - 540	1	72	95%
541 - 600	2	74	98%
600 - 1149	2	76	100%

Significant conclusions from Table 2 data:

90% of CSO rainfalls of 360 minutes (6 hrs) or less
98% of CSO rainfalls of 600 minutes (10 hrs) or less
100% of CSO rainfalls of 20 hours or less
Average rainfall duration during period = 157 minutes
Total time of CSO rainfalls during period = 14,424 minutes = approx. 240 hours/yr
76 CSO rainfall days during period; long-term ave. = 130 days/yr rainfall>0.25 mm

Calculated Volume Needed for Domestic Wastewater Detention System. Based on the above timing and an estimated future average indoor domestic discharge of 170-220 l/day from a dwelling unit, the following required detention volumes are calculated using the higher value:

(6 hr/24 hr)(220 l/day) = 55 litres required detention to bridge 90% of CSO storms (6)

(10 hr/24 hr)(220 l/day) = 92 litres required detention to bridge 98% of CSO storms (7)

Full detention = 220 litres required detention to bridge 100% of CSO storms (8)

In source control practice, volumes of domestic wastewater as above would need to be detained during CSO storms in order to avoid mixing with storm drainage. Ordinarily, it is not desirable to store wastewaters for more than about 6 hours due to septicity, however, based on the above watershed data, this would be only a 10% occurrence. It is further to be recognized that domestic wastewater flows vary during the day and generally follow a pattern of initial peak flows during a period from about 6:00 to 10:00 a.m. with secondary peak flows during a period from about 5:00 to 7:00 p.m. in USA cities. This variation in flow rates would of course need to be considered in the design of the on-site detention facilities.

SOURCE CONTROL FACILITIES AND CONTROL STRATEGY

Physical facilities for on-site detention

It is not the intent here to provide design and operation details for the necessary on-site source control detention systems. However, it is expected that tanks or buffering storage devices can be developed as needed. On-site as used here refers to detention facilities constructed in or on a source property, such as in a house or building structure, sewer service lines, and nearby detention facilities which may actually be off of the source property, but situated such as to prevent or delay mixing with stormwater in combined sewers.

Control strategy for operation of on-site detention facilities

Assuming the appropriate physical design and development of on-site storage facilities, fill and release strategies would be needed to control the system. Possible strategies are listed below:

Fill Activation Strategy Basis:

- Accumulative rainfall depth
- Rainfall intensity
- Combined sewer flow rate or depth
- Signal from CSO control system
- Public education on usage

Release Strategy Basis:

- Decrease in rainfall depth
- Decrease in rainfall intensity
- Combined sewer flow rate or depth
- Signal from CSO control system
- Public education on usage

SUMMARY AND CONCLUSIONS

This paper has provided an analysis of the source control of domestic wastewater so as to avoid its mixing with storm water which results in the formation of combined sewage and associated CSO sanitation problems. Expected reductions in domestic water demand in the USA due to redesign of plumbing fixtures will have dramatic effects on wastewater discharge and CSOs, particularly due to increases in pollutant concentrations. Typical data indicate that the effects of CSOs in receiving waters can be reduced through the detention of domestic wastewater during stormwater flow periods, with later release after peak periods. It was shown that the more frequent lower CSOs are more significantly affected by the mixture of domestic wastewater with stormwater flows than with the less frequent more highly diluted large CSOs. The main advantages of wastewater source control are in reducing the pollutant concentrations in CSOs. Domestic wastewater flow rates (i.e., 1.0 DWF) are generally small as compared with rainfall runoff rates from intense storms which may range up to 100 DWF or more depending on combined sewer capacities. So the idea would not appreciably reduce CSO volumes, but would reduce CSO pollutant concentrations. In conclusion, it is believed that cost-effective approaches for reducing CSO volumes can be achieved through the integrated source control of both wastewaters and storm waters.

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